WAR-TIME MODEL HOPPER UNIT FOR BURNING VARIOUS FORMS OF WOOD IN STANDARD DOMESTIC FURNACES

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WAR-TIME MODEL

HOPPER UNIT FOR BURNING VARIOUS FORMS OF WOOD IN STANDARD DOMESTIC FURNACES

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The initial objective of the investigations covered by this report was to explore the possibilities of using shavings accumulated at various war contract plants for domestic furnace fuel. Many inquiries have been received at the Forest Products Laboratory as to what can be done to dispose of them without undue expense. Being potentially good dry fuel that rides to market on the back of lumber, so to speak, especially in the case of hardwoods, without extra labor for cutting it seemed that shavings might find a place to supplement war-time coal and oil supplies.

The firing of loose shavings in the ordinary domestic heating plant was out of the question. In view of the many commercial attempts briquetting seemed to offer little prospect of success except the special type of briquetting developed on the West Coast for use where very large concentrations of shavings and specialized high pressure machinery are at hand. Hence, thought turned toward a method for burning shavings in the form of compressed bales as commonly produced with ordinary baling equipment already at hand at many plants. This would involve a hopper unit attachable to a standard furnace. So far as was known this alternative had not previously been investigated for shavings although hopper units were known to be applicable to both sawdust and stove wood.

Avoidance of the use of critical materials in the form of cast-iron parts or heavy gauge sheet metal was an essential requirement for the investigation.

The work done on a unit to burn baled shavings has had reasonable success and, as it turns out, the unit is also well adapted to loose shavings, sawdust, chunk wood, and almost any other

form of wood. Probably the most significant fact is the latitude afforded for the burning of various forms of wood. Whereas all the forms of wood fuel would not be at hand in any given locality there are many instances where it would be advantageous to use two forms in supplement of each other, as will be discussed under a later heading.

There has been considerable research and commercial development of sawdust burners for domestic furnaces, particularly in the Pacific Northwest[1]. Literature from England describes methods whereby sawdust can be burned in stoves and furnaces as a wartime measure[2]. Also recent research has been carried out in Connecticut on a furnace attachment for the more efficient burning of stove wood in domestic heating plants[3]. It is impossible to say how well the unit described here burns each fuel in comparison with the other more specialized units. Theoretically the present unit is deficient in certain features for the most efficient combustion. It is believed, however, that the universal unit lends itself to reasonably good operation and to simple design and construction features to the point of its being readily assembled from standard non-critical materials and without the purchase of any special parts.

The necessity of feeding through a wide-open top to admit the common standard 14 by 18 by 32-inch fifty-pound bale of shavings and also the necessity of avoiding the use of cast-iron parts for feed door and fittings meant that it was necessary to face the proposition of air leakages through non-seated joints at the top of the unit. This led to the idea of down-draft burning through a channel provided through the fuel in lieu of the more usual up-draft. It was soon found that down draft with its avoidance of grates was not only expedient but quite essential to the burning of some of the combinations of fuel forms that it is desirable to utilize.

Previous research, both here and abroad, has shown that the high volatile content which characterizes wood fuel requires a

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[1] "Rating and Care of Domestic Sawdust Burners" by E. C. Willey, Bulletin No. 15 Engineering Experiment Station, Oregon State College, Corvallis, Oregon.

[2] "Furnace and Stove for Burning Sawdust", Leaflet 26, Forest Products Laboratories, Princes Risborough, Bucks, England.

[3] "A Wood-Burning Conversion Unit for Household Furnaces" by Henry W. Hicock, A. Richard Olson, and Lauren E. Seeley, Bulletin 463, Connecticut Agricultural Experiment Station, New Haven, Conn.

predominance of secondary air[4] to primary air[5] at a ratio of about 4 to 1. As it passes for a distance of about 5 inches through the glowing coal zone in a wood fire, the carbon dioxide formed in burning is changed to carbon monoxide to which additional oxygen must be supplied for complete combustion. It has been the recognized practice in efficient wood stove design, particularly in the so-called slow combustion type of European stove, to admit the required secondary air from below close to the fire zone but between the fuel bed and the chimney. In a hopper burner for fine fuel inclined to "arch", admitting air from below increases the tendency to smoke and blow back (back-fire) and also requires a close balance between secondary and primary air. With the down draft as used in this unit there is no separation of secondary and primary air. The method of filling the unit as described for each form of fuel is aimed to provide that the bulk of the draft acts as secondary air by passing around and over rather than through the burning bed of fuel. To a large measure the effectiveness of this type of burner is due to the use of firebrick in lieu of metal for the walls of the combustion chamber, particularly in the burning of green fuel. The firebricks hold and reflect heat for a long period and aid greatly in the complete use of the combustible volatiles.

Capacity and Performance of Unit

No pretense is made that the unit as described gives the closely-controlled, free-of-attention burning that one expects of an oil burner, stoker, or even hand-fired coal. It is not intended so much for those who may have the option of the above as for those who have access to wood supplies of one kind or another and want to realize on some of the advantages that wood fuel has, including in some circumstances lower cost and greater cleanliness.

Without war-time restrictions on materials and parts it should be possible to modify the design features for greater peacetime convenience.

The unit as tested is primarily intended for use in the ordinary five or six-room house where the firepot of the furnace will vary from 17 to 22 inches inside diameter. The size of the furnace and of the ash-pit door opening through which the unit connects with the furnace dictates the size and some of the

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[4] Air admitted to the fire zone not passing through the fuel.

[5] Air passing through the fuel bed.

construction features of the unit. Clearance for access to the flue clean-out door on the furnace is a factor affecting the height of the hopper. The unit as described has been built in connection with a 17-inch firepot having an ash-pit opening of 11 by 14 inches and is just the right size to accommodate a common standard bale of shavings.

For the conditions as above the inside dimensions of the auxiliary unit are approximately 18 by 18 by 35 inches. This gives a capacity of about 125 to 150 pounds of chunk wood, 50 to 60 pounds of baled or packed-in shavings, 70 to 80 pounds of green sawdust, or proportionate amounts of the above when used in mixtures.

Using a furnace-dome temperature of 200°F. as a normal operating heat requirement a charge of chunk wood is found to burn for about 10 to 12 hours and the other finer forms of fuel about 5 hours. Thus an over-night charge, at least with chunk wood, is made possible. Within the operating periods as given there may be variations of 20° or more in the dome temperatures although considerably less in the room temperatures. Thus one of the disadvantages of wood fuel - that of varying temperature is not eliminated by this unit as now built.

Construction of the Unit

The unit is an insulated rectangular brick-lined chamber resting directly on the concrete floor, connecting with the furnace through a tunnel through the ash-pit door and closable at the top by a heat-resistant slab cover built in three sections for most convenient handling. There are no grates. Draft is controlled by the tightness with which the three sections of the top are brought together. The three sections of the top are comparable to the lids on a kitchen range except that setting them ajar increases the rate of burning instead of checking it as in an ordinary stove. The unit may be considered in general terms as a "Dutch oven", but actually the method of burning is quite different in principle.

If there are coal grates in the furnace, it is highly desirable to remove them unless they are already burned out and worthless for re-use with coal.

The brick lining of the chamber is made of standard size firebrick laid flatwise. The brick may be laid up with fire clay or loose without mortar. The latter was used in the experimental model and is considered to have worth while advantage.

Prior to laying up the chamber the ash-pit door casing is lined with standard size firebrick so laid as to form as large a tunnel as possible between the furnace and the hopper. In the illustration accompanying this report the division of the tunnel into two ducts is, of course, necessary because of the need for building the top of the tunnel from standard-size firebrick.

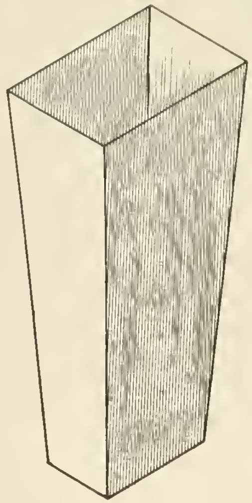
After the brickwork is in place an outer jacket casing is erected around three sides of the chamber leaving about 4 inches between the chamber and the jacket into which dry asbestos fiber is tightly packed to provide insulation and additional airtightness and support for the brickwork of the lining. The asbestos fill is also packed in on the furnace side of the unit between the brick lining and the iron front of the furnace. The outer jacket can well be of asbestos cement board of the "transite" type. This is probably the cheapest, most convenient, and satisfactory jacket material in the absence of sheet iron. For use where the transite board is not available a more cumbersome outer wall can be built of common brick leaving the same space for fill insulation between the inner and outer walls.

Where the outer casing is built of transite the transite panels may be screwed to a light angle-iron frame. This is undoubtedly best if 1/4-inch transite is the only thickness available. If it is 1/2-inch transite, it may be butted against stops on the furnace jacket and tightly banded with metal package strapping without the use of metal framing. The latter method has been used in the experimental unit and is considered satisfactory.

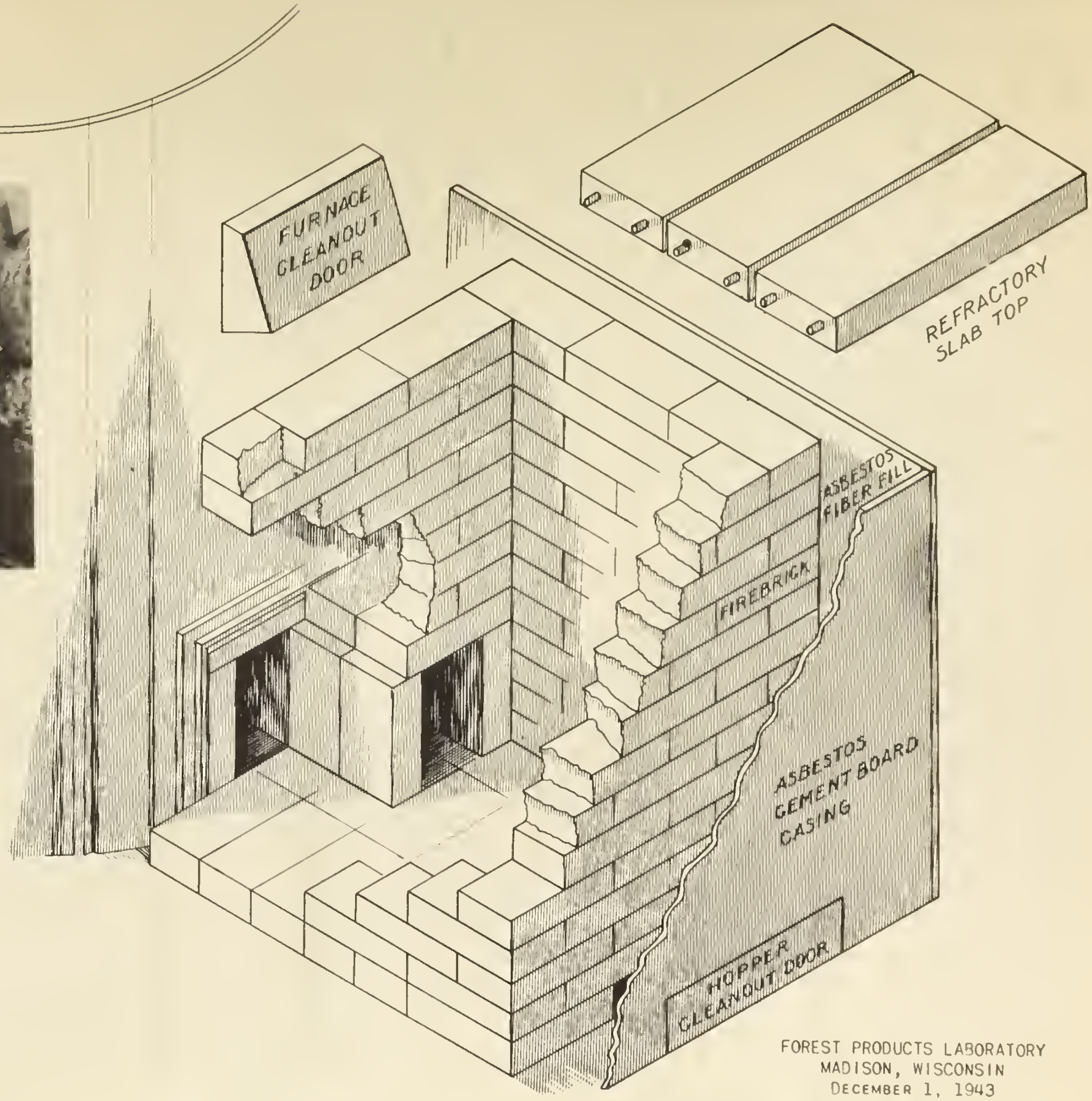
Because this unit does not rely on up draft through grates removal of the relatively little ash produced from wood fuel does not require much special provision. A small port at the floor line may be left for this purpose in both the brick lining and outer casing. This port can be stopped by a tight-fitting sheet metal cover to eliminate air leakage. Another method is to omit the port and lift the ash from the top with a lift-shovel. This is easier to build and nearly as convenient as the other method.

The top and feed door of the unit as mentioned previously consists of three cast slabs made from heat-resistant cement such as Firecrete. They simply rest on the top of the brickwork. The slabs are sufficiently reinforced with metal to withstand handling and bridging across the top of the unit without breakage. The slabs are cast approximately 2 inches thick. Each slab, about 2 by 7 by 20 inches, is somewhat cumbersome to handle but nevertheless not too heavy to lift without strain.

A piece of auxiliary equipment required for use with sawdust or loose shavings, as will be described later, consists of a light



REMOVABLE SHEET METAL
FORM FOR USE WITH SAWDUST



FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN
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HOPPER UNIT OF NON-CRITICAL MATERIALS FOR CONVERTING
A STANDARD DOMESTIC FURNACE TO BURN WOOD WASTE AND SOLID WOOD

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sheet metal form around which the loose fuel is packed and which is then withdrawn to leave a definite flue or channel through the fuel. This metal form is tapered for ready withdrawal from the compressed fuel bed. It is approximately 5 by 10 inches at the bottom and 8 by 12 inches at the top and long enough to extend from the floor of the chamber to the top of the fuel charge. This is a feature suggested by literature on sawdust burning from England. An ordinary stove pipe was originally used, but the tapered duct works better.

General Operating Requirements

In starting or between refills when the house temperature is considerably below the desired normal and it is necessary to bring the temperature up as quickly as possible, the quick heat should be provided by a fast-burning, split-wood fire in the bottom of the hopper. Only when the temperature of the house and the heating system is nearly up to normal should the full hopper charge be put in. This would be the case with almost any hopper unit for wood fuel. Although much the same principle applies to the hand firing of coal or coke it is particularly true of wood that when a large mass is burning hard there is little chance to throttle it down to the normal operating level.

The first basic rule, therefore, should be to produce the quick heat from a small fast-burning fire, fill the hopper on the bed of embers, and then throttle down for a steady rate of burning.

The second basic rule is that with down-draft burning a well-defined open channel must be provided from the top of the charge to the bottom tunnel opening. With fine compressible fuels, sawdust and shavings, this is accomplished by the use of the removable metal flue as described below. With sticks of wood which are piled in individually it is essential to pile as compactly as possible but leave a definite channel from top to bottom on the furnace side of the hopper. Sixteen-inch wood piled in at right angles to the front of the furnace leaves a 2-inch channel which is just about right. With baled shavings the size of the bale in relation to the size of the hopper must provide for this vertical channel.

With all of the forms of fuel the first step in loading the hopper is to push the live embers of the previous charge forward as far as possible to the mouth of the ash-pit tunnel. Accumulation of dead ash in front of the tunnel should be pushed to the rear of the unit. In filling the hopper a space of 1 or 2 inches should always be left between the cover and the charge of fuel.

When the metal flue is to be used it should be placed against the furnace side of the hopper and resting on top of the embers. The fresh charge of fuel is then dumped in and pressed down firmly with any tamping tool, particularly around the flue itself, so as to form a compressed or packed zone which will hold in place when the flue is withdrawn. With any reasonable care the tapered metal flue can be easily withdrawn without causing the sawdust or shavings to fall down and fill up the channel. The burning of the charge will begin immediately in this channel. If through carelessness in withdrawing the flue the channel has been partially filled up, then the air cannot get down to the live-coal zone at the bottom and a smoldering fire results which will smoke back through the top of the hopper. If the fall-in is such that it does not quickly burn itself through, a small hole an inch or two in diameter can be poked through to the mouth of the tunnel to open it up. When this is done the channel will soon burn itself wide open. After the burning starts within this channel there is little likelihood of its becoming filled in again from falling fuel.

Draft is regulated by changing the spacing of the three sections of the refractory cover. Crude as this arrangement is, it works fairly well. There is some air-leakage even when the three sections are brought together as tightly as possible. However, considerable flexibility of control results from the size of the opening left between the sections and whether an opening is left immediately over the front channel or over the portion farthest from the furnace. The pull of the chimney is such that the ingoing air has a fairly concentrated blast effect on the body of fuel. It has been found that admitting the air through an opening all the way across the top as a curtain draft works better than using a more localized opening or hole in the middle which gives a jet draft.

With a three-section top the possible openings are here designated as 1, 2, 3, 4, numbering from the furnace side.

No. 1 concentrates the draft straight down the channel along the brickwall which is most advantageous for charges of solid wood which need to be prevented from burning too fast.

No. 2 concentrates the draft down the face of the fuel in the channel which is most advantageous during the first part of a run of sawdust or shavings.

No. 3 concentrates the draft on top of the charge which is advantageous only when the channel has become enlarged in the middle of the sawdust or shavings run. This opening is used when starting the fire in the base of the unit for kindling or quick heat.

No. 4 concentrates the draft across the top of the charge which is advantageous only in the later stages of a run.

It is desirable to use the different draft openings according to the fuel used and to the progress of the burning.

A quarter-inch opening between the sections is a usual spacing although more or less is sometimes required. The regulation of the chimney damper will vary with the particular installation. Proper adjustment and balance with the air inlet is important, probably more so than in the ordinary furnace. In the case of a charge of solid wood that has burned off most of the volatile and is in the charcoal stage the damper can be throttled down to a considerable degree. However, if it is throttled before the volatile is burned and while there is considerable long flame, the damper shouldnot be closed too much. Otherwise the flames tend to rise in the hopper instead of being drawn down into the tunnel and will throw out occasional puffs of smoke. To reduce the rate of burning while the fuel is in the long-flame stage it is better to reduce the air entrance and confine it to the No. 1 opening rather than to close off the chimney damper too much.

It is always better to make gradual changes in the settings of the draft and damper rather than sudden ones.

Special Requirements for Various Forms of Wood

Baled shavings.--The size of the bale varies somewhat among different companies, but a 14 by 18 by 32-inch size weighing about fifty pounds is a common standard, at least in the Mid-West. This happens to be a size that is well adapted to the hopper unit that would be built in connection with a furnace for a five- or six-room house (17 to 20-inch firepot size). In an 18 by 18 by 35-inch hopper a 4-inch clearance between bale and front wall of the hopper is thus provided for the down-draft channel. Any excess height of the bale should be removed so as to leave at least a 1-inch free space between top of charge and the cover of the hopper.

A fifty-pound bale will give about a five-hour charge at a moderate rate of combustion. As the front of the bale burns away and the size of the channel increases, the rate of burning tends to decrease. To maintain a brisk rate of burning after the first hour or so it is frequently necessary to drop two or three pieces of stove wood into the channel area. Depending on the amount of feeder fuel that is thus added this restores the original rate of burning and holds a more uniform combustion for the remainder of the charge.

The loading of a fifty-pound bale into the top of the hopper is, of course, a somewhat clumsy operation. A fairly convenient method is to use a buggy or wheeled table the height of the hopper from which to slide the bale into the unit. The baling wire is not removed from the bale. A bale half the height of the hopper, so that two bales instead of one would constitute a charge, would be best, but the cost of baling would be somewhat increased and at present it is probably out of the question.

Loose shavings.--Packing loose shavings into the hopper permits a charge of about fifty pounds, or the equivalent of a bale. The removable metal flue is used in this case as elsewhere described. The combustion is confined to the channel zone, and takes place at about the same rate as a charge of baled shavings, viz., about five hours. For continued rapid combustion after the first hour a few sticks of solid wood may be needed in the channel as described for bales.

The use of loose shavings has the distinct disadvantage that refilling is dangerous unless special precautions are taken to guard against flash ignition of dry loose shavings in contact with the hot embers in the hopper. If proper precaution is taken, it is not dangerous but carelessness can lead to trouble, especially if one leans over the hopper when filling.

The proper procedure is, first, to put the metal flue in place and cover the embers outside the flue with a couple of pails of shavings which have been dampened or exposed to the weather enough to settle dust and kill flash ignition. The main charge can then be put in without danger. Outdoor or shed storage of shavings is undoubtedly best from all angles. Storage and handling of loose shavings in the house basement are certainly not to be recommended.

A convenient handling procedure is to use a loading box of about one-half the hopper capacity which is somewhat smaller than the hopper and built with flaring sides and a loose push-in bottom held by a narrow flange. The shavings can be packed into this box at the storage pile. It can then be inverted open end down into the hopper and the shavings pushed out by pressing in the bottom. The top dimensions of the container should be such as to readily go down into the hopper when the metal flue is in place.

Sawdust.--Sawdust fresh from the log (not rain-soaked) will provide about a sixty to eighty-pound charge in this unit lasting for about five hours. The removable metal flue is used, as previously described. A few sticks of solid wood dropped into the channel are used for the middle and latter

part of the combustion period as in the case with shavings. Ordinarily more supplementary solid wood is required than with shavings because of the higher moisture content of the sawdust. The fuel value of green sawdust per pound is not as great as that of dry shavings, but the use of sawdust obviates some of the drawbacks connected with shavings.

For a brisk burning rate the sawdust should be merely firmed down and not packed down hard in the hopper except around the metal flue. A packed-down charge will amount to about a 90-pound loading, but the burning will be too slow except as supplementary solid wood is added in considerable amount. For mild weather overnight burning this may prove satisfactory in some cases.

Another method of operating this unit with sawdust is described under items below where it is used in combination with dry small fuel that otherwise tends to burn too rapidly.

Chunk wood.--From 125 to 150 pounds of solid chunk wood can be loaded into the hopper. This will provide a 10- to 12-hour charge at normal operating temperatures. Normally chunk wood will not be thoroughly dry, and will not pile into the hopper without a few large voids through or around the charge. Hence, a definite channel zone down the front of the pile is not as important in this case as with finer, drier sticks. If the chunk wood is very green, an intermixing of some ordinary-size stove wood through the pile is advantageous.

Green chunk wood of oak, birch, maple, and hickory has been burned satisfactorily in this unit. Dry wood is, of course, better than green from the standpoint of its heat value.

Stove wood.--Split or smooth round wood approximately 5 inches in cross section makes a compact charge of 125 to 150 pounds and gives good burning performance. It should be piled to give the 2- to 3-inch channel on the furnace side of the hopper. If, however, the wood is rough and crooked so as not to pile compactly and if it is also so dry that it tends to burn fast, then it is recommended that sawdust be shoveled in on top of the charge until the voids through and around the load are filled, except for the channel zone.

Bundled edgings.--Such material will normally make a compact hopper load and will accommodate around 125 pounds which will burn approximately 12 hours. The charge should be compactly piled leaving the channel open on the furnace side. If they are dry edgings and of such shape that they do not pile compactly, all voids should be filled in with sawdust.

Slabs.--Usually there are more voids in a pile of slabwood than most other forms because the pieces do not nest completely. Whether the slabwood is green or dry it should be piled as compactly as possible leaving the open channel on the furnace side. If the slabwood is rather fine, dry, and tends to burn fast, it should be layered with sawdust, except for the channel, to reduce the rate of burning. Even green slabwood may benefit from filling the voids with sawdust.

Mill and shop trims.--Short and miscellaneous-size pieces that can be handled only in the bulk rather than by placement of individual sticks should be used only as a layering with sawdust which is dumped into the hopper around the removable metal flue. Without a large proportion of sawdust the voids through the charge will be excessive and the burning will take place too rapidly for a full hopper charge. After the blocks and sawdust are in place the metal flue is withdrawn.

Short trims are apt to be dry material. Hopper burning is not recommended except in combination with sawdust. A hopper charge may consist of about 100 pounds, half block and half sawdust. Such a charge will burn from 6 to 8 hours. The proportions of solid wood and sawdust can be varied according to the experience and desire of the operator provided enough sawdust is used to fill the voids. A large proportion of sawdust can be used if the blocks are merely mixed in as the hopper is filled.

Material Requirements and Costs

For construction of the unit as described the following items are listed to show approximate quantities and costs:

Firebrick - 180 standards, 20 splits	$20.00
Asbestos fiber - 300 pounds	9.00
Asbestos cement board of "transite" type - 1 sheet (1/2 inch by 42 inches by 96 inches)	7.00
Refractory cement of "Firecrete" type - 1 bag (100 pounds)	4.50
Reënforcing rods or pipe for cover slabs	1.00
Metal strapping - 75 feet	1.00
3/4-inch angle iron - 12 feet) Metal screws - 12)	1.00

Approximately one man-day labor is required for construction.

All of these items are standard commercial materials, and are understood not to be on current scarcity lists with possible

exception of the metal strapping. In smaller communities some of the items will have to be ordered from the district jobbers of boiler plant supplies.

Additional comment on each item follows:

Firebrick.--Common or building brick is not an alternate for this purpose. New brick rather than used brick is recommended because of greater ease in placement. If new brick is used, it is considered entirely practical to build the hopper without cementing the joints.

Asbestos fiber insulation.--Other non-combustible insulating materials may be usable in lieu of asbestos fiber. However, there seems little likelihood that other insulations will be more available or cheaper. It is understood that the supply of asbestos short-fiber is "easy." Sand in lieu of asbestos fiber has been tried out, but is not considered satisfactory.

Asbestos cement board.--There is one well-known brand of this material that is commonly known as Transite. It is more generally available in 1/4-inch thickness than in 1/2 inch, but the former cannot be used without a supporting frame in the proposed construction. Hence, the latter is recommended as the easiest and cheapest construction.

This type of board can be cut with a hand saw, but with considerable difficulty and damage to the saw teeth. If a special abrasive wheel is not available for this purpose, it is better to cut by scoring deeply on both sides with a sharp tool and then breaking carefully as in the cutting of glass.

Refractory cement is needed for making the three cover sections. There are several types of refractory cement, some of which will set and harden without heat, like concrete, and some require furnace baking. Only the former type is recommended for this purpose. A well-known commercial brand of this type is known as "Firecrete" and has been found satisfactory for this purpose. It comes in 100-pound bags. Only about 50 pounds will be required for one set of covers, but it is strongly recommended that two sets be made up so that a spare set will be immediately available in case of breakage or damage to the original set.

An alternate and perhaps better method of making the sectional covers is to use 1-inch to 1-1/2-inch angle iron to make tray-like frames into each of which five firebrick "splits" will fit. Asbestos cement can then be troweled over the top of the brick

to close the joints and give additional insulation. A two-section top will conform better than three sections to the use of full size brick without cutting. Handles for lifting should, of course, be provided.

Reënforcing rod.--Putting metal reënforcement in cement slabs subjected to high temperatures is not considered good practice because of the tendency for the metal to twist and break the cement. However, no difficulty has been encountered under the conditions described for this unit. One-half-inch scrap iron pipe has been used in this case with satisfactory results. Probably any similar reënforcing rod or wire will work equally well. Replacement of any damaged slab cover presents no serious difficulties.

Metal strapping as used with a strap-fastening tool for boxes and crates is the type here referred to. It is used for holding the three sides of the casing together and for tying the casing to the jacket of the furnace. The use of metal strapping is by far the most simple and effective method, but wire of the type used for baling can be substituted if strapping is not available. Wedging to take up the slack may be necessary if wire banding is used.

Angle iron.--A strip extending from the floor line to the top rim is screwed to the jacket of the furnace at each side of the front to provide a stop against which the transite casing boards are abutted and pulled tight. If necessary, a strip of transite can be used for this purpose, but light angle iron is preferable. After screw holes are punched in the sheet metal jacket of the furnace, metal screws are used to hold the angle iron firmly in place. The screw fastenings are supplemented by metal straps or wires extending around the furnace. The strapping around the casing of the hopper thus pulls against the strapping around the furnace jacket.

General Conclusions

The unit as described appears to offer an effective method of burning in a standard warm-air furnace the forms of wood that, in war time in particular, stand the best chance of being available -- factory waste in the city, mill waste in the sawmill town, or cordwood in the farm community. Its war-time application due to shortages of oil and coal is of first consideration. However, with some modification and refinement peace-time applications may prove of significance in connection with improved forest utilization.

The unit provides the means of realizing good combustion of the high volatile content of wood fuel in the relatively small combustion chambers of warm-air furnaces built for coal or oil. It goes quite a way in overcoming the usual disadvantages of burning wood due to necessity of frequent re-fueling and to difficulties in controlling the rate of burning and makes possible the realization of the advantages of wood fuel that lie in its cleanliness and ease of ash disposal.

The construction is such that an individual with a fuel supply available to him can build his own unit without having to rely on a manufacturer for special parts. However, if any concern has regular quantities of wood or waste that it wants to develop a market for, it will probably be necessary to help make it easy for the potential consumer to equip himself with a unit and also to initially demonstrate its installation to the extent of the consumption that the supplier can serve.